DUAL MODE POWER MANAGEMENT SYSTEM

Field of the Invention

This invention relates in general to power generation and regulation circuits and more particularly to an improved low voltage, low power generation and regulation circuit.

Background of the Invention

In portable battery operated products such as a wireless selective call capable device, many attempts have been made to design circuits that effectively control and distribute power to functional circuits within the device. Prior art systems have used both capacitive and inductive topology voltage multipliers for generating voltages necessary to power such devices as microcomputers, information displays, linear support circuits for power distribution and management, as well as signal processors. However, a persistent problem has been that the efficiency of such voltage multipliers is typically low, thus resulting in an unnecessary loss of power when used to supply said devices.

Thus, what is needed is an efficient apparatus that not only generates the necessary voltage supplies, but also intelligently selects the most efficient voltage supply available for powering such devices.

Brief Description of the Drawings

FIG. 1 is a block diagram of a selective call receiver in accordance with the preferred embodiment of the present invention.

FIG. 2 is a block diagram of an intelligent power source selection circuit in accordance with the preferred embodiment of the present invention.

FIG. 3 is a schematic diagram of a switching circuit associated with the intelligent power source selection circuit illustrated in FIG. 2.

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FIG. 4 is a flow diagram illustrating operation of the intelligent power source selection circuit shown in FIG. 2, in accordance with the preferred embodiment of the present invention.

FIG. 5 is a graphical illustration of operating regions associated with the intelligent power source selection circuit shown in FIG. 2, in accordance with the preferred embodiment of the present invention.

Description of a Preferred Embodiment

Referring to FIG. 1, a battery **100** powered selective call receiver comprises an antenna **110** coupled to a receiver **108**. The receiver **108** is coupled to a main control board **114** which may strobe the receiver on and off for power saving purposes. Furthermore, the receiver **108** couples received information to the main control board **114** where it is routed to the demodulator for processing and recovery of modulated information that may be presented to a user in any number of formats such as audio, text, video, etc.

A support circuit **104** may, and in this case does supply a multiplied voltage V_{dd} **106** to a microcontroller **112** as well as a power management circuit **126** known interchangeably hereafter as an intelligent power source selection circuit **126**. The power management circuit **126** has inputs of a battery voltage V_{bat} **102** and the multiplied voltage from the support circuit. In the preferred embodiment of the present invention, the power management circuit **126** distributes power to at least the demodulator **122**, a decoder **124**, and oscillator **118**, a PLL (Phase Locked Loop) **120**, and an SPI (Serial Peripheral Interface) **116**. Alternatively, the power management circuit **126** would also supply power to the microcontroller **112**. These devices are arranged such that the selective call receiver can operate to receive radio frequency signals and recover information contained therein for presentation to the user in any number of formats as detailed above.

Referring to FIG. 2, the illustration shows a block diagram of the intelligent power source selection circuit

126 in accordance with the preferred embodiment of the present invention.

The intelligent power source selection circuit **126** operates using the battery **100**, a microcontroller programmed (or fixed) voltage reference **200**, and the multiplied voltage V_{dd} **106**. The primary purpose of the intelligent power source selection circuit **126** is to select the most efficient power source and supply that selected source to circuits associated with the portable communication or other portable device. By doing this, the time between either battery replacement or charging is significantly extended, thus making the device using this intelligent power source selection circuit **126** more desirable to a portable device user. Marketing studies have determined that a majority of portable device users will select a device that has a longer battery life over one with a shorter battery life. Therefore, devices using the present invention, considering that all other operational aspects of similar devices remain equal, will be selected by users over devices not having the present invention.

Operationally, the battery **100** is coupled to an input **102** of an output selector **204** as well as to an input of a comparator **202** having a predetermined hysteresis characteristic **202**. Further, the multiplied voltage V_{dd} **106** is coupled to the output selector **204**. The microcontroller programmed (or fixed) voltage reference **200** is coupled to both the comparator **202** and a voltage following operational amplifier **206** that generates an output reference voltage $V_{ref'}$ **210** which substantially follows a reference voltage V_{ref} **208**. The output voltage $V_{ref'}$ **210** is then coupled to the output selector **204**. Based on the flow diagram shown in FIG. 4, and in response to a magnitude of the battery voltage V_{bat} **102** and the reference voltage V_{ref} **208**, the comparator **202** operates to couple a selection signal to the output selector **204** which in turn selects the most efficient voltage supply from the multiplied voltage V_{dd} **106** and the battery voltage V_{bat} **102** as V_{out} **212**. Selection as described here always insures that the minimum amount of power is drawn from the ineffcient multiplied voltage supply over time. Thus, the battery or other primary power source will

last longer since the amount of power lost to inefficient multiplier conversions is always minimized.

Referring to FIG. 3, a schematic diagram illustrates the internals of the output selector **204** which comprises a switching circuit associated with the intelligent power source selection circuit **126**.

First, the output reference voltage V_{ref}, **210** is coupled to the inputs of two parallel transmission gates **302**, **304**. These transmission gates are controlled by the comparator's **202** selection signal such that when the signal is in a first state (low), transmission gate **302** is activated which couples the output reference voltage V_{ref} **210** to switch **306**, coupling the battery voltage V_{bat} **102** as a supply for V_{out} **212** which supplies a regulated voltage to circuitry within the portable device. When the comparator's **202** selection signal is in a second state (high), transmission gate **304** is activated which couples the output reference voltage V_{ref} **210** to switch **308**, coupling the multiplied voltage V_{dd} **106** as a supply for V_{out} **212** which supplies a regulated voltage to circuitry within the portable device. To prevent the generation of noise or glitches on the selected power output, the comparator has a predetermined amount of hysteresis such that the battery voltage V_{bat} **102** must traverse a hysteresis window before selection of the less efficient power supply occurs. Similarly, when and if the battery voltage V_{bat} **102** recovers from a drop caused by events such as a high current demand by the portable device's circuitry, the battery voltage must again traverse the hysteresis window before selection of the more efficient power supply occurs. In this manner, the circuitry powered by this invention is subjected to minimal interference due to power supply switching transients.

Referring to FIG. 4, a flow diagram illustrates operation of the intelligent power source selection circuit **126** in accordance with the preferred embodiment of the present invention.

At power up **402**, the circuit tests **404** to see if the battery voltage V_{bat} **102** is greater than the output reference voltage V_{ref} **210** plus the predetermined hysteresis. If this is true, the output is selected **406** to source the battery

voltage V_{bat} **102** as V_{out} **212**. If this test fails, the output is selected **408** to source the multiplied voltage V_{dd} **106** as V_{out} **212**. Once V_{out} **212** is selected as the multiplied voltage V_{dd} **106**, the battery voltage V_{bat} **102** is tested **410** until it's magnitude is greater than a sum of the output reference voltage V_{ref} **210** and the predetermined hysteresis. When that condition is true, the output is selected **406** to source the battery voltage V_{bat} **102** as V_{out} **212**. However, if the test fails, the intelligent power source selection circuit **126** will continue to source V_{out} **212** as the multiplied voltage V_{dd} **106**.

Referring to FIG. 5, a graphical illustration shows the regions associated with operation of the intelligent power source selection circuit **126** in accordance with the preferred embodiment of the present invention.

Region 1 **500** as shown in FIG. 5 is typically known as a startup region. In this region **500**, power has just been activated to the circuitry associated with the portable device. Curve **502** shows the battery or primary power source voltage V_{bat} **102** which rises rapidly to a point above a regulated voltage V_{out} **212** shown as curve **504**. Since the multiplied voltage V_{dd} **106** shown as curve **506** is well below the regulated voltage V_{out} **212** shown as curve **504** in this region, only one choice for the regulated voltage V_{out} **212** supply is possible and it is the battery voltage V_{bat} **102**. In region 2 **508**, the battery voltage V_{bat} **102** remains above the regulated voltage V_{out} **212** and thus, power for regulated voltage V_{out} **212** is still derived from the battery voltage V_{bat} **102**. Not until the point shown as **512** does the battery voltage V_{bat} **102** fall below the predetermined hysteresis limit of the comparator **202**, at which time the intelligent power source selection circuit **126** operates to select the multiplied voltage V_{dd} **106** as a supply for V_{out} **212**. In region 3 **510**, the battery voltage V_{bat} **102** remains below the regulated voltage V_{out} **212** and not until the battery voltage V_{bat} **102** reaches above the point where it exceeds the sum of the regulated voltage V_{out} **212** and the predetermined hysteresis limit of the comparator **202**, does the intelligent power source selection circuit **126** operate again to select

the battery voltage V_{bat} **102** as a supply for the regulated voltage V_{out} **212**.

As one of ordinary skill in the art would appreciate, the implementation described here is but one way to realize the claimed invention. More particularly, any semiconductor technology, e.g., CMOS, bipolar, etc,. may be used to fabricate elements such as the transmission gates **302**, **304**, power switches **306**, **308**, amplifier **206**, comparator **202**, or associated components such as the receiver **108**, demodulator **122**, support circuit **104**, decoder **124**, and microcontroller **112**. Moreover, it is contemplated that the present invention be used in conjunction with portable electronic devices such as pagers, advanced messaging devices (1-way and 2-way), smart cards, cellular and other portable telephones, personal digital assistants, and all forms of portable computing devices. Any device that requires a stable regulated voltage supply will benefit from the use of the present invention because the useful operating life of a portable device will be extended between either battery replacements or charges.

What is claimed is: